Engineering Economy

Chapter 11: Breakeven and Sensitivity Analysis

The objective of Chapter 11 is to illustrate breakeven and sensitivity methods for investigating variability in outcomes of engineering projects.

To this point we have assumed a high degree of confidence in estimated values.

- The degree of confidence is sometimes called *assumed certainty*, and decisions made on the basis of this kind of analysis are called *decisions under certainty*.
- In virtually all situations, ultimate economic results are unknown.
- Breakeven and sensitivity analysis are used to help understand how our decision might be affected if our original estimates are incorrect.

The *breakeven point* is the value of a key factor at which we are indifferent between two alternatives (one may be "do nothing").

$$EW_A = f_1(y) \text{ and } EW_B = f_2(y)$$

$$\begin{aligned} EW_A &= \text{equivalent worth calculation of alternative } A \\ EW_B &= \text{equivalent worth calculation of alternative } B \\ y &= \text{a common factor of interest of } EW_A \text{ and } EW_B \end{aligned}$$

The breakeven point is the value of *y* where

$$EW_A = EW_B \text{ or } f_1(y) = f_2(y)$$

Common factors to consider for breakeven analysis.

- annual revenue and expenses
- rate of return
- market (or salvage) value
- equipment life
- capacity utilization

Should I sell my gas-guzzler?

My 1998 minivan is quite functional, but it only averages 20 miles per gallon (mpg). I have found a somewhat newer vehicle (roughly the same functionality) that averages 26 mpg. I can sell my current minivan for $2800 and purchase the newer vehicle for $4,000. Assume a cost of gasoline $4.00 per gallon How many miles per year must I drive if I want to recover my investment in three years? Assume an interest rate of 6%, zero salvage value for either vehicle after three years, and identical maintenance cost.

Gas-guzzler solution

Current minivan

$$PW_1 = \$2,800 + \left(\frac{x}{20}\right)(\$4.00)(P/A, 6\%, 3)$$

New vehicle

$$PW_2 = \$4,000 + \left(\frac{x}{26}\right)(\$4.00)(P/A, 6\%, 3)$$

Equating these, and solving for *x*, we find

$$x = 9,729 \ miles/year$$

We use sensitivity analysis to see what happens to project profitability when the estimated value of study factors are changed.

- What if expenses are 10% higher than expected—is the project profitable?
- What if sales revenue is 15% lower than expected?
- What change in either expenses or revenues will cause the project to be unprofitable (*decision reversal*)?

Reconsidering my gas-guzzler.

Considering that I drive about 10,000 miles per year, our previous analysis would indicate that I should purchase the vehicle that gets better mileage. However, what if gas prices drop by 10%? Should I still sell my gas-guzzling minivan?

$$PW_1 = \$2,800 + \left(\frac{x}{20}\right)(\$3.60)(P/A, 6\%, 3)$$

$$PW_2 = \$4,000 + \left(\frac{x}{26}\right)(\$3.60)(P/A, 6\%, 3)$$

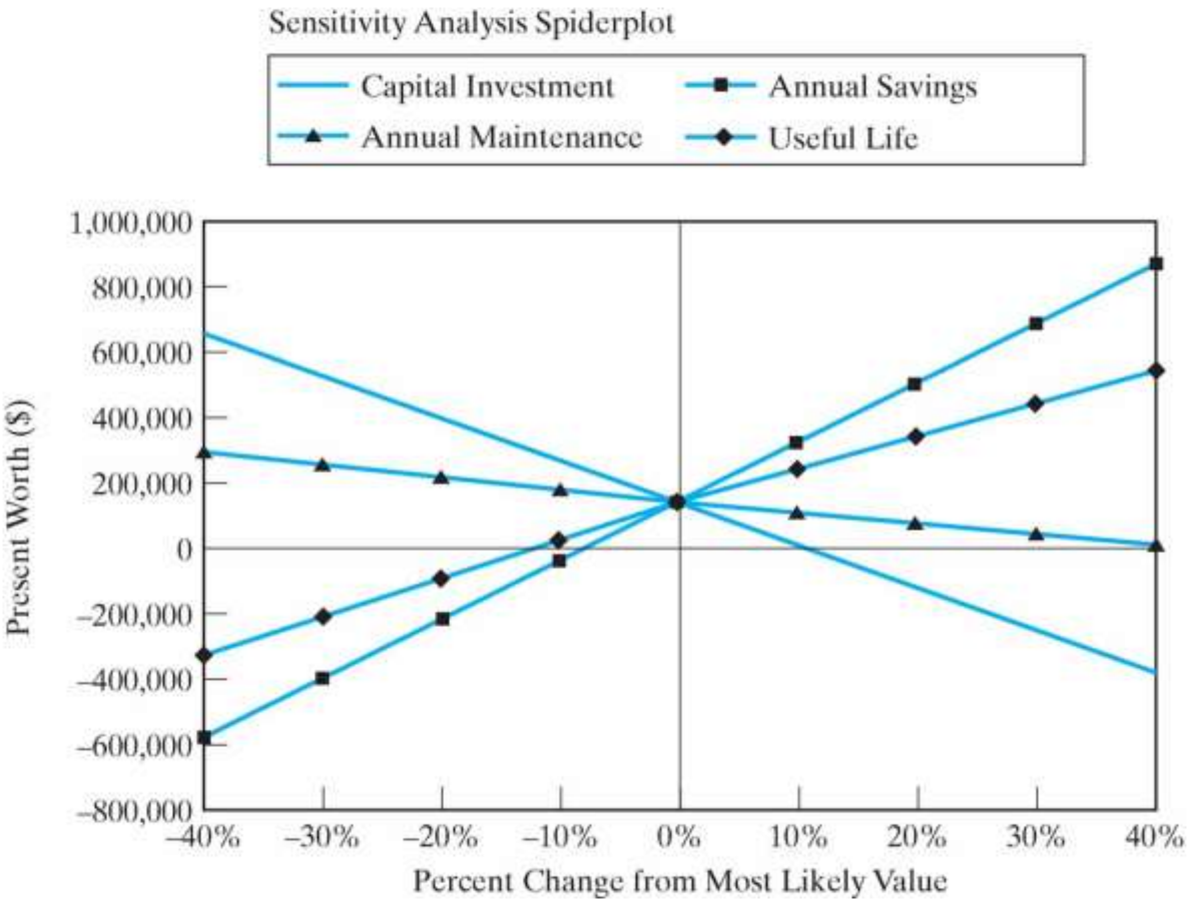
$$x = 10,806 \ miles/year$$

So, if gas prices drop by 10%, I should keep my minivan.

Spreadsheets are very useful in performing sensitivity analysis.

- Formulas easily reflect changes in parameter values.
- Tables and plots can provide quick answers and visual cues to the effect of changes.
- A spider plot can be especially useful in sensitivity studies.
- It can be useful to examine more than one alternative on a plot, or to examine sensitivity of incremental cash flows.

[Note that the steeper the curve, the more sensitive is the PW to the factor.]



Changing the value of more than one factor at a time.

- To this point we have only looked at changes in one factor at a time.
- In reality, each factor considered can change, so it is useful to look at the effect of simultaneous changes in factors of interest.
- One way to accomplish this is to use the *Optimistic-Most Likely-Pessimistic* (*O-ML-P*) technique.

Optimistic-Most Likely-Pessimistic

- Establish *optimistic* (the most favorable), *most likely*, and *pessimistic* (the least favorable) estimates for each factor.
- The *optimistic condition*, which should occur about 1 time out of twenty, is when all factors are at their *optimistic* levels. Similarly for *pessimistic condition*.
- The *most likely* condition should occur roughly 18 times out of 20.
- Perform *EW* calculations under each condition for insight into the sensitivity of the solution.
- The results can be seen on a spider plot for further insight.

Consider investment in a new crane. Assume a MARR of 8%.

	Estimation Condition		
	Optimistic (O)	Most Likely (M)	Pessimistic (P)
Investment, *I*	$240,000	$270,000	$340,000
Useful life, *N*	10 yr	8 yr	5 yr
Market value, *MV*	$20,000	$15,000	$8,000
Annual revenues, *R*	$100,000	$80,000	$50,000
Annual expenses, *E*	$10,000	$15,000	$20,000

Considering *O*-*ML*-*P* for *I* and *R* (fix *E*, *MV*, and life at their *ML* levels). Value in each cell is the PW for the project.

	Investment, *I*		
Revenues, *R*	Optimistic (*O*)	Most Likely (*M*)	Pessimistic (*P*)
Optimistic, (*O*)	$256,568	$226,568	$156,568
Most Likely, (*M*)	$141,636	$111,636	$41,636
Pessimistic, (*P*)	-$30,764	-$60,764	-$130,764

This suggests that perhaps some additional effort should be place on getting refined estimates of revenues. Of course, the complete study needs to consider the other factors.